Asploro Journal of Biomedical and Clinical Case Reports
(ISSN: 2582-0370)
Case Report
DOI: https://doi.org/10.36502/2025/ASJBCCR.6428

Investigation of Glucose Fluctuation by Continuous Glucose Monitoring (CGM) Using Smartphone

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Received date: 08 September 2025; **Accepted date**: 04 October 2025; **Published date**: 11 October 2025

Citation: Bando H, Urasaki H, Bando M. Investigation of Glucose Fluctuation by Continuous Glucose Monitoring (CGM) Using Smartphone. Asp Biomed Clin Case Rep. 2025 Oct 11;8(3):282-86.

Abstract

Using the medical apparatus FreeStyle Libre 3 with smartphone as Continuous Glucose Monitoring (CGM), detailed blood glucose variability was studied. Current case is a registered nurse aged 59 years who has been treated with some oral hypoglycemic agents (OHAs). Her diabetic state has been stable with HbA1c 6.6–6.9%. The purpose was to monitor the glucose fluctuation in response to various food intake. Post-prandial hyperglycemia (PPH) was observed by carbohydrate intake, such as rice, bread, and noodles. By drinking pre-prandial milk 70 cc just before 3 meals a day, PPH showed enough reduction, which suggests a clinically beneficial effect of milk from now.

Keywords

FreeStyle Libre 3, Smartphone, Continuous Glucose Monitoring, Post-Prandial Hyperglycemia, Pre-Prandial Milk

Abbreviations

CGM: Continuous Glucose Monitoring; PPH: Post-Prandial Hyperglycemia

Introduction

Standard diabetic management has been announced annually by the American Diabetes Association (ADA) for years, and the latest version was presented in Jan 2025 [1]. For detailed analysis of blood glucose, blood glucose monitoring (BGM) and intermittently scanned continuous glucose monitoring (isCGM) have been known for diabetic patients [2]. Related topics include examining several personalized models for CGM [3]. Along with the development of CGM, some CGM types such as Dexcom G7 and FreeStyle Libre have been investigated [4].

Authors and collaborators have been involved in diabetology and atherosclerotic cardiovascular diseases (ASCVD) for a long time [5]. We have proposed useful low carbohydrate diet (LCD) methods including super-, standard-, and petite-LCD [6]. In addition, some papers concerning CGM were reported with various discussions [7,8]. Recently, we had an impressive opportunity of CGM by smartphone, in which a registered nurse applied FreeStyle Libre 3 and obtained detailed glucose variability. Then, its general progress and related perspectives are described in this article.

Case presentation

Case and Method:

The current case was a registered nurse aged 59 years. She has been treated for type 2 diabetes (T2D) for 9 years and provided with some oral hypoglycemic agents (OHAs). They include metformin 500 mg, vildagliptin 100 mg, and occasional miglitol 50 mg 1–2 times a day. Her BMI has been 23.5 kg/m^2, and HbA1c has been recently around 6.6–6.9% without specific diabetic complications.

As this project for glucose variability, she used FreeStyle Libre 3 for 7 days in July 2025. She could manage adequate usage of Libre 3 [9]. As the purpose of this study, she pursued the detailed differences in blood glucose due to several trials of taking foods or liquids such as bread, rice, and noodles as carbohydrates in her daily life.

Results

The glucose variability measured by FreeStyle Libre 3 was shown on July 18th and 19th (**Fig-1**). The patient took bread for breakfast on July 18th, resulting in persisting post-prandial hyperglycemia (PPH) for rather long hours. On the other hand, she had hamburger steak, salad, and cheesecake for lunch. The content was relatively low in carbohydrates, leading to a short period of PPH. On July 19th, she revealed acute glucose elevation in breakfast from 100 mg/dL to 250 mg/dL for a short time. The content included bread, banana, yogurt, and café au lait, which were quickly absorbed. Her lunch was a usual Japanese-style lunch box with 85 g carbohydrates, café au lait with 6 g carbohydrates, and Japanese cake with 15 g carbohydrates, totaling 105 g of carbohydrates. PPH showed an increase to 280 mg/dL, lasting 4–5 hours, which seems to be from the rice and other carbohydrates in the lunch box. Thus, PPH persisted for a rather longer time, since rice may be absorbed more slowly than other carbohydrates.

The glucose variability on July 20th and 21st was shown in **Fig-2**. She took low-carb ramen (Japanese noodles) for lunch. Regular ramen contains about 60 g of carbohydrates, while low-carb ramen has 15 g, about 75% less. Since carbohydrate 1 g can raise blood glucose by 3 mg/dL in T2D, 15 g of carbohydrates may elevate blood sugar about 45 mg/dL. Actually, blood glucose was elevated from 98 mg/dL to 150 mg/dL, rising 52

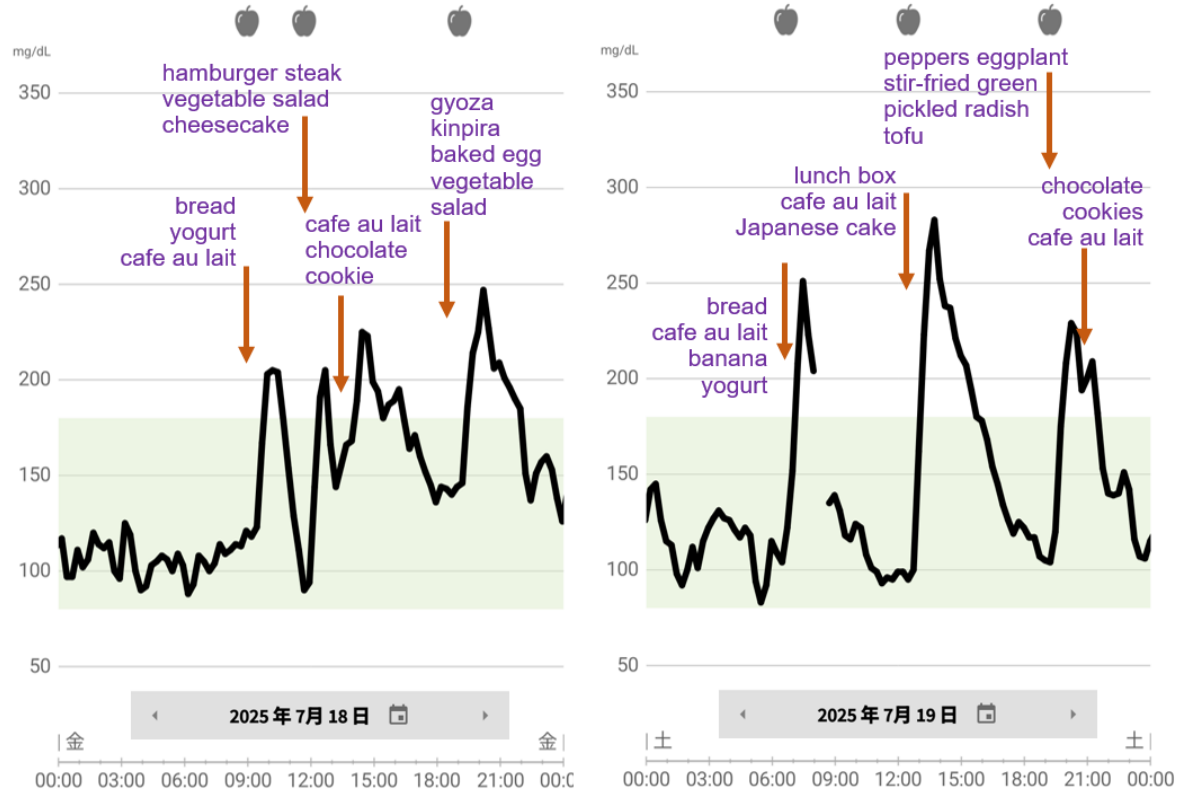

Fig-1: CGM Data by Smartphone -1

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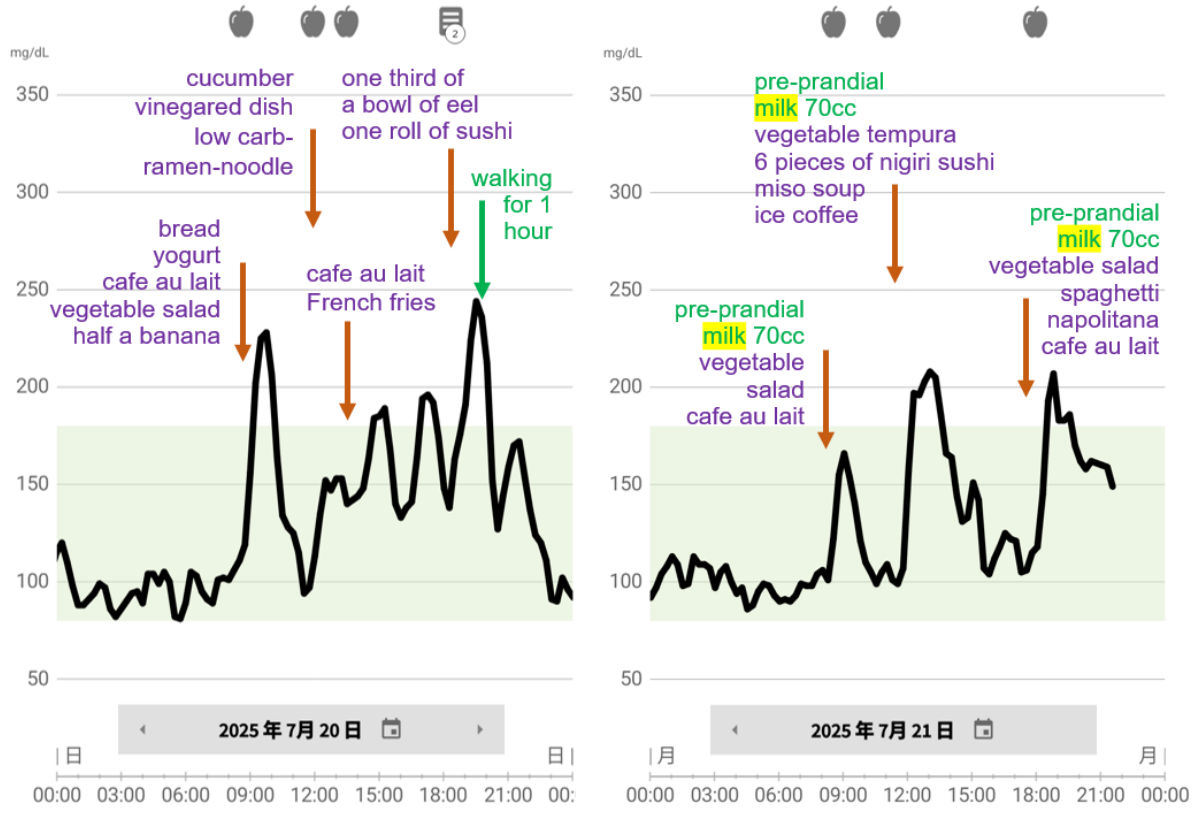

Fig-2: CGM Data by smartphone -2

mg/dL. Furthermore, walking for one hour after dinner brought a drop in blood glucose rather rapidly. On July 21st, pre-prandial drinking of 70 cc of milk was tried three times a day. Even though she took sushi (Japanese vinegar rice and raw fish) for lunch and spaghetti for dinner, her blood glucose did not rise too quickly. Her typical breakfast is shown in **Fig-3**. The ingredients and carbohydrate amounts are as follows: milk 3 g, vegetable salad 2 g, cooked egg 1.5 g, low-carb yogurt 5.5 g (38% less carbohydrate than conventional), bread 25 g, and café au lait 6 g.

Fig-3: Typical Breakfast for the Case

Discussion

For decades, the CGM system has been widely known, and its quality has become more convenient by taking most advantage of smartphones. All required results are analyzed and sent via the internet. The FreeStyle Libre 3 system is equipped with a sensor and an app that are sufficient for usual clinical use. The sensor is set on the back of the upper arm without pain, and glucose variability data are sent to the smartphone automatically. Several beneficial aspects seem to be painless, accurate, discreet, affordable, and provide real-time glucose results at a glance. CGM has become more convenient for analyzing glucose variability in diabetic patients [10]. With the development of Artificial Intelligence (AI), healthcare has provided medical technique revolutions leading to health challenges, well-being, and system performance [11]. Furthermore, precision medicine and rapid drug delivery systems (DDS) have been found. Adequate application of AI will bring broad potential opportunities that will emphasize operational efficiency, health outcomes, and patient care.

In this study, PPH was observed when carbohydrates

such as rice, noodles, bread, and others were ingested. Japanese food has been known for its higher carbohydrate content. On the other hand, low-carb noodles showed less response of PPH compared with usual noodles. As 1 g of carbohydrate is taken, blood glucose will rise 3 mg/dL for T2D and 1 mg/dL for healthy persons [12]. From this background, we continue the activities of the Japan LCD Promotion Association (JLCDPA) and recommend three useful methods. They are super-, standard-, and petite-LCD, which include 12%, 26%, and 40% of carbohydrate ratio, respectively.

Pre-prandial milk intake suppressed PPH in this case. While α-glucosidase inhibitors (α-GI) such as voglibose and miglitol can decrease PPH, taking milk has also been known to show a similar clinical effect. Some reports are found concerning the milk effect. A comparative study of breakfast with dairy products was performed among 3 groups of none, 1, or 2 dairy servings [13]. As a result, total glucose area under the curve (AUC) was lower in 1-D and 2-D than none-D ($p<0.05$). Consequently, the replacement of carb-rich breakfast components with 1-2 dairy servings can reduce PPH and improve glycemic control. In the latest study, whey protein was served before breakfast in doses of 0, 10, 15, 20, and 30 g, and the degree of PPH was investigated [14]. The incremental AUC was reduced by taking 15–30 g of whey protein. In detail, premeal intake of 30 g whey protein showed dose-dependent reduction for glucose peak with a maximum of -36 mg/dL (-2.0 mmol/L).

Some limitations may exist in this report. CGM has been applied for useful evaluation of glucose variability. However, it would not be enough for just measuring, but detailed judgment for carbohydrate intake and behavioral modification will be required. Adequate meal selection can be expected by the application of CGM.

In summary, CGM with smartphones will become a more convenient apparatus for diabetic patients, related persons, and caregivers. Effective and meaningful application can be expected, because precise data can be obtained immediately. These continuations will bring health and well-being for each individual and welfare in our society.

Conflict of Interest

The authors have read and approved the final version of the manuscript. The authors have no conflicts of interest to declare.

Funding

There was no funding received for this paper.

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